Background

During recent years, soil has received increased recognition at local, regional, state, national and international scales as an important natural resource. For example, the Food and Agriculture Organization (FAO) of the United Nations declared 2015 the "International Year of Soils". Those actions were followed by: (1) the Noble Foundation and the Farm Foundation, in cooperation with several public and private-sector stakeholders identifying soil as one of America’s most important natural resources and announcing steps to work toward their long-term health and sustainable use by creating the Soil Health Institute in 2015, (2) an International Union of Soil Science (IUSS) declaration that 2015 through 2024 would be the “International Decade of Soils,” (3) formation of an interagency working group that developed a framework to improve coordination of federally funded soil science research, and (4) initiation of the Healthy Soils, Thriving Farms Challenge area as one of the key strategic scientific priorities identified by the Foundation for Food and Agricultural Research (FFAR) which was established through bipartisan support in the 2014 U.S. Farm Bill. By creating the Healthy Soils, Thriving Farms Challenge area, FFAR also concluded that soil science research and development needed better coordination, evaluation, and implementation to advance soil conservation and management throughout the U.S. Collectively, all of these efforts were designed to increase public- and private-sector interest in, and advance the scientific understanding of, soil resources so that land managers and farmers can have the information they need to improve their management of these important resources.

At FFAR, we recognize there are a number of critical challenges and key scientific priority areas through which FFAR and other key stakeholders can partner to become change agents focused on advancing soil health. In addition, the challenge of increasing food production must be addressed while maintaining productivity of the land through sustained and improved soil health. FFAR is uniquely positioned to exist in a pre-competitive space and to work with a wide range of stakeholders to address these soil health challenges and opportunities through public/private partnerships. This can be done by funding projects that foster innovation in areas that can result in positive changes to soil health. We also recognize that it is important to
identify areas where FFAR can leverage resources to support transformative and innovative research with a targeted outcome of creating healthy soils.

Transformative Spaces

It is imperative that there be an increase in agricultural productivity in the near future to not only address food production demands associated with an increasing global population, but also to address increasing protein, fiber, and fuel demands an increasing environment stress. One of the key components required to increase and maintain productivity is healthy soils. Soil Health encompass biological, chemical, and physical properties and processes that must all be improved, generally through a systems or interdisciplinary approach to management. At FFAR, we recognize how integral the farm is to a healthy soil ecosystem, while also acknowledging that many of the benefits of healthy soils extend well beyond the farm to include provision of multiple ecosystem services.

The science of soil health is ever-evolving. Historically, the terms “soil health” and “soil quality” have identified physical, chemical and biological properties and processes that contribute to soil function. While each of those components have long histories of research, combining them into one concept is a more recent evolution in how soil science is addressing productivity. There is a strongly articulated need from stakeholders, including academia and industry, as well as local, state and federal government personnel, land managers and farmers for accurate, standardized, and cost-effective in-field soil health measurements and improved methods for interpretation. The fact that field-ready assessment strategies remain in their infancy— in fact for many soils and systems they have not been developed or implemented on a practical scale—limits the ability of the agricultural decision maker to formulate timely management responses that support healthy soil practices. Assessment tools will draw on improvements in the science and technology that support sustainable land management practices, including applied research, data acquisition, storage, and interpretation as well as management strategies that foster collaboration among stakeholders and garner of broader support for sustainable land management practices. To facilitate the adoption of more responsive soil health practices, we must support innovative and transformative research focused on biological, chemical and computation sciences that place a national emphasis on appropriate soil health metrics. There is also a need for new advances in modeling, remote sensing, and monitoring to not only quantify the current state of soil health, but also develop a predictive understanding of concepts that allow us to wisely steward our soils.
Solution: The Research Landscape Approach

To address the challenges associated with encouraging and supporting soil health, FFAR coordinated an innovative series of stakeholder engagement activities to identify and develop an efficient and appropriate program that would embody the Healthy Soils, Thriving Farms Challenge Area. Through a series of open sessions, invited stakeholder meetings, and one on one consultations with experts in various agricultural disciplines, feedback identifying research gaps was obtained and used to develop and support transformative and innovative research targets. The product of those stakeholder assessments, in combination with canvassing the organizations and individuals active within the soil health research landscape, has led to the development of several key areas that we at FFAR believe should be addressed through a comprehensive, science-based soil health program using a landscape approach. The major components identified for the Healthy Soils Thriving Farms strategic framework were synthesized from the stakeholder input, thus helping ensure buy in for investment in a series of topic areas to address research gaps where FFAR can potentially influence transformative research and development within a well-defined precompetitive space.

About the Healthy Soils, Thriving Farms Research Landscape Approach

FFAR seeks to support collaborative research centered on thriving farms to address soil health challenges, with an emphasis on integrated public-private partnerships. The Healthy Soils, Thriving Farms Scientific Program will focus on applied research projects that contribute to understanding and improving soil health, while addressing the social and economic realities that challenge farmers, ranchers, private businesses and other stakeholders. Through the development of a comprehensive program that supports soil health, FFAR will address six priority areas where advances in knowledge are very likely to support thriving farms. The FFAR program is designed to foster adoption of science, management strategies, technologies, and training and outreach that not only encourage sustainable practices but also support thriving farms as the centerpiece of a comprehensive soil health program. The anticipated outcome of this landscape approach is to make thriving farms a key component of healthy, economically viable soil ecosystems.

Program Priorities

Soil Health Indicators

As soil health cannot be measured directly, it is important to develop and evaluate indicators that accurately and efficiently assess soil health and can be used to guide land managers and farmers toward more effective soil and crop management practices. Studies are needed to identify effective soil health indicators, to document cost-effective and accurate measurement strategies, and to provide guidelines that clearly document progress toward improved soil health. Science-based comparisons of existing and emerging soil health indicators is needed to move laboratory/greenhouse evaluations to the field. Increased capture and use of data describing soil health as it varies within the soil profile and across the landscapes is needed to monitor soil health under dynamic land-use. Additional translational research is needed along with greater investment in research and development of soil health benchmarks and associated interpretive frameworks.
Data Collection and Management

A key component for advancing soil health is a deeper understanding of the long-term effects of land use and land cover change. Expanded data collection, storage, and retrieval is integral for developing more accurate assessment and predictive models of various soil health conditions. However, given the scale of data requirements for rigorous and meaningful analysis, these efforts will be highly dependent upon collaborative public private partnerships to ensure access to all of the essential data and effective data management practices.

Soil Enhancing Techniques

Increasing adoption of Soil Health improving practices is an integrative process that if properly executed can provide economic, social and environmental benefits. Applied research that supports development and implementation of metrics and practices that optimize nutrient use efficiency by meeting crop requirements while minimizing nutrient losses is a critical component of effective landscape-scale soil health. Research that provides additional insight into local soil and climatic conditions, crop, as well agronomic and conservation practices, such as no-till farming and the use of cover crops, will also play a vital role within FFAR’s Healthy Soils, Thriving Farms Challenge Area.

Ecosystem Services

Appropriate valuation of ecosystem services is also important, because without it the brunt of soil degradation and loss of soil as natural capital tends to be borne by the public sector. When not properly valued, ignoring ecosystem services presents a disincentive for land managers between the inherent benefits of adopting practices that promote soil health versus continuing business as usual. As a result, the value of soil ecosystem services tend not to be adequately assessed in large part due to the invisible nature of these services. This often includes awareness of pest and disease suppression, carbon sequestration, and natural regulation of nutrients and water and uptake processes. Without question, it is imperative that all ecosystem services be valued as an integral component of a comprehensive soil health program. There is a need for development and implementation of management strategies that maximize the ability of soil to provide future services and to preserve the soil from long term detrimental effects (Finvers, 2008). There is also a need for additional research to improve fundamental understanding of ecosystem services associated with soil health, and to develop relevant indicators to measure and monitor ecosystem services.

Assessment of the Costs and Benefits of Soil Health Practice Adoption

Current business models between landowners, farmers, and agricultural retailers do not adequately encourage soil health management. Conservation systems and practices to restore soil health introduce potential operational complexities, and may require farmers to make higher capital or variable cost outlays in the short term. Recouping these investments requires a longer planning horizon which
mandates research that supports farmers in making these long-term soil health investments. There is a strong need for economic research on the long-term benefits to the farmer – how does improved soil health, that can be tracked by standard indicators, align with cost savings such as reduced fertilizer or pesticide inputs, and/or crops that are more resilient to climate stress? How do policies, standards and branding influence soil health outcomes? This integration of science and implementation is essential. Additional research into these socio-economic spaces will be an invaluable component of the soil health landscape.

**Training**

As we improve the metrics and methodologies we use to understand how to more effectively assess and improve soil health, another key component is a well-trained workforce of researchers, crop and farm advisors, as well as well-trained soil health decision makers. This priority area seeks to promote innovative outreach, education, and training projects. FFAR’s Healthy Soils, Thriving Farms projects will seek to reach new demographics and communities and encourage the adoption of activities that promote soil health. Programs should assess efficacy of education and outreach methods to inform recommendations for improvements. FFAR sees value in funding applied science that allows new information to be quickly and effectively put into the hands of land managers, ranchers, and farmers. On-farm demonstrations serve as one of the most effective tools to test innovation on the ground and serves as an integral component of a comprehensive program of developing and promoting healthy soil practices. This should be a key component of any training, provided the demonstrations are conducted in a replicable and scientifically sound manner.

**Conclusions**

FFAR’s Healthy Soils, Thriving Farms Challenge Area is open to a broad range of ideas that by no means are exhaustively outlined in these priority areas. However, these areas do represent FFAR’s commitment to the needs expressed by our stakeholders and generally available spaces in the precompetitive research world where our impact may be the most substantial.

**Citations**